CHAPTER 33

CHANGES IN ENVIRONMENT: IMPLICATIONS FOR FISHERIES IN INDIAN WATERS

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Introduction

The coastal and marine ecosystems are dynamic and the seasonal and inter-annual fluctuations of the abiotic ecological parameters reflect on the biological functioning of the plankton, nekton and all other biota. Apart from the natural variations, anthropogenic impacts including climate change and habitat degradations and alterations have affected the sustainability, productivity and diversity of almost all critical habitats like the mangroves, sea grasses and the coral reefs. Each critical habitat has its own unique characteristics and the biota which depend on these have suitable adaptive characters to survive, grow and reproduce in these. However, variations which are significantly wide and large lead to mis-matches eco-biological links. These affect the recruitment of the species which cascades down the food web and the fisheries. Some of the major environmental factors are the monsoon and upwelling and specifically, if we take environmental variables like sea surface temperature, oxygen, salinity and nutrients. Similarly habitat alterations due to marine litter and shrinking of habitats due to land filling and other activities have severely affected the estuarine fauna.

The Indian fisheries is composed of major small pelagic fishes like sardine, mackerel and anchovies; the large pelagic like the tunas and bill fishes, several demersals and shellfishes. Also, the ecological characters of the west coast which is influenced by upwelling is different from east coast. A brief description of the variations in environmental factors and their impact on the fisheries is given below.

Natural variations in ecosystems and impacts on fisheries

Upwelling and fisheries

Upwelling is a process in which deep, cold water rises toward the surface. Upwelling occurs when winds push surface water away from the shore and are replaced by cold, nutrient-rich water that wells up from below. Deep ocean water is more nutrient-rich than surface water as nutrients, dead and decaying plankton and other fish carcasses sink to the bottom. During upwelling these are brought back to the surface and these fertile systems support blooming of diatoms and zooplankton. This rich food supports growth and maturation of several fishes. Along the Indian west coast, upwelling is strong along Kerala coast and is known to occur in varying intensities. El-Nino has been found to affect the intensity of upwelling.

Along Kerala –Karnataka coast upwelling sets in by May –June and the rich food available prepares the pelagic fishes especially sardine for spawning. When upwelling is poor, the major factors supporting gonad development like blooming of diatoms and lowering of ambient temperature does not happen and this can lead to poor maturation or delayed maturation. In 2015, upwelling was poor and maturation was affected.

Upwelling can also bring in low oxygen water which can lead to hypoxic conditions. Sometimes along Kerala coast, low oxygen in upwelled waters can be seen in the sardine habitat during August –September. If the dissolved oxygen levels are below one ml /l then this has been found to affect recruitment and the fishery. Low mixing of waters can cause stratification and along with hypoxic conditions cause stress to the early life stages.

Monsoon and Fisheries

When maturation is largely influenced by upwelling, the onset and intensity of southwest monsoon has a good influence on spawning and recruitment of pelagic fishes like sardine. Though there is no direct affect, the changes triggered by monsoon especially the blooming of plankton in near-shore waters supports early larval development. The high levels of phosphate, nitrate and silicate in the river runoff triggers and supports blooming of diatoms. These support the large shoals of early life stages of sardine. Similarly, there will be negative impacts when the river runoff is high and there is no proper mixing. This can lead to stratification and adversely affect recruitment.

Temperature-Food combination and links with El nino

Globally, 2015 has been considered as a warm year with high temperature and low food. The average seawater temperature in sardine habitat was 29.8^{o} C during 2015, which is nearly 1.1 ^{o}C higher than the average observed (28.6^{o} C) for the last 5 years. Positive SSTA exceeding 0.6 ^{o}C dominated in the tropical Indian Ocean. There was a substantial warming in the tropical Indian Ocean, partially due to influences of the 2015 El Nino. The mean SST in the tropical Indian Ocean was reported to increase by 0.13-0.2^{o}C in 2015. Phytoplankton density was also low during April/ May 2015 compared to the high during 2012. This low food availability in the habitat was found to affect maturation which resulted in poor recruitment.

Environment changes and recruitment

Two important theories in ecology have been found to be applicable to the Indian fisheries scenario. The theory of Optimal Environmental Window (OEW) states that in upwelling.

Systems, wind, storm, and other energetic events cause turbulence that, within an optimal range, increase larval recruitment; dependent upon the presence/ absences of Ekman transport. When the optimal ranges are absent, the larvae does not get recruited to the fishery. Similarly, the Match-mismatch hypothesis of the British biologist cusing where the success of larval recruitment is linked to a temporal alignment of fish reproducing, larvae hatching, and plankton blooming has also been found to be relevant in the Indian context.

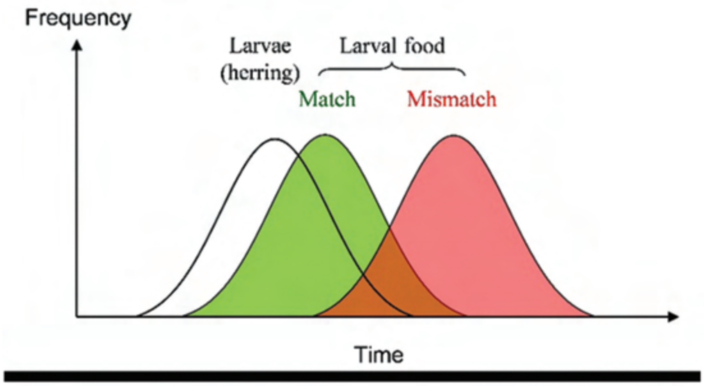

Fig 1. An increase of the time-lag between the two populations leads to a low match. Adapted from Cushing (1990)

Anthropogenic impacts on Environment and fisheries

Impact of litter – physical changes

Light weight articles which are discarded on land or directly into the aquatic systems float (floating litter) and are transported as per the direction of wind and slowly with attachment of silt they sink down (Column litter) and float in the water column. (*Example- The weight of a plastic cover which is approximately 3.8 g has been found to increase to 8 g and float in the column before settling)*. With time, it sinks and spreads on the bottom and creates anoxic conditions which prevent oxygenation and lead to anoxic conditions thereby displacing the benthic community (Bottom litter). Within the aquatic systems, floating litter can also get accumulated in certain pockets where water movement is less, especially near the shore and remain there for years together, these can be called "Biologically Dead Zones".

When water flow is less like in the dead zones, growth of zooplankton will be less and prevent light penetration which is essential for a healthy ecosystem. This will affect fishes and fish larvae. Evidently this reduces the beauty of the area and if uncontrolled, can lead to decline in visits tourists, thereby affecting those who depend on tourism industry. Globally it has been estimated that 70% of the litter sinks down and destroys the substratum.

Fishes which substrate spawners like Karimeen (Pearl spot/*Etroplus suratensis*) have drastically declined and this has affected the small scale fishery. The breeding areas of such fishes have been affected by dumping of solid waste and poor water quality. These fishes attach their eggs to rocks or hard substrates and need shady and protective areas for rearing their young ones. Now severe destruction of benthic habitat has reduced congenial area for breeding and nursery of young fishes. These fishes lay only few eggs, for example, one pearl spot produces about 2700 eggs per spawning which is low compared to fishes like mullets and sardines. Hence these are more vulnerable to habitat loss.

Floating and submerged debris has reduced the habitat area available for the fishes and thus has reduced the biomass of fishes. The commercially important benthic resources like crabs, shrimps and clams are the most affected by benthic habitat destruction. Dumping of solid waste from slaughter houses and its decaying also adds to poor water quality. Clogging of canals by plastics and other litter has led to increased sedimentation and reduced the depth of the estuary. Lack of water flow has caused low oxygen condition which has also reduced the quantity of plankton available as food for the fishes.

The surveys conducted on the seed availability have clearly indicated a significant decline in seed resources of all species of shrimps in Vembanad Lake. *Peneaus* (*Fennerpenaeus*) *indicus*, *Penaeus mondoan*, *Metapenaeus dobsoni*, *Metapenaeus monoceros* and *Metapenaeus affinis*. This is reflected in the shrimp catches of stake net units where the catch per unit effort has declined from 3.2 kg in 1997 to an average of 0.508 kg indicating nearly 84% decline.

The abundance of all species of shrimp seed in Cochin backwaters has declined drastically during the last two and half decades. Surveys conducted in 2013 have indicated that the major resources like white shrimp (*Fenneropenaeus indicus* and *Metapenaeus dobsoni*) have declined. Shrimp seed mainly feed on detritus; now the backwaters substrates have considerable quantity of litter. Survey results have indicated that traditional shrimp farms are affected by low shrimp seed availability.

When efforts are made to remove solid waste from land, there are no programs for removing litter accumulated in rivers, estuaries and sea. Since estuaries which are critical habitats are already impacted by untreated effluents from industries, direct dumping of solid wastes, invasion of aquatic weeds, reduced water flow, high siltation and landing filling there is an urgent need to initiate programs to control these and start restoration programs.

Fig. 2. A branch of estuarine canal completely clogged by invasive aquatic weed in Cochin backwaters

Habitat alterations

Shrinking of estuarine areas due to reclamation, sand mining, excessive sedimentation due to physical manmade barriers and degradation of critical habitats like mangroves and sea grasses have affected the structure and ecosystem services of these aquatic systems. The most affected areas are the coastal wet lands. The increase in floating weeds and clogging of estuarine branches by the invasion of these weeds have affected fishers, especially the clam fishers.

Increasing incidences of harmful algal blooms

Globally, the intensity and frequency of occurrence of HABs have increased. Indian fisheries is also affected by blooms of *Noctiluca* sp, *Tricodesmium* sp and other dinoflagellate blooms. These reduce the diversity of phytoplankton community and create imbalances in the plankton community. These are found more during the late monsoon or early pre monsoon which is a major spawning period of both pelagic and demersal fishes.

Increasing incidences of jelly fishes

Along both the coasts, the jelly fishes have increased in number. Only few species bloom. But the occurrence of hydrozoan and schyphozoan medusae in the coastal waters have led to decrease in fishing days and also low fish catches in seines and trawlers. The spread of jelly fishes in the estuarine areas due to salinity intrusion has also created considerable problems to inshore gill netters. Globally jellyfishes are considered as a threat to fisheries. The major reasons for this new problem is considered as eutrophication, increased episodes of hypoxic conditions and spread of underwater structures which serve as a niche for the dormant stages of jellyfishes.

Conclusion

The influence of environmental variations on the productivity of the aquatic systems and the fishery of the area has become more evident now. The impact of fluctuations in seasons and intensity of natural ecological variations on the recruitment of major fishery resources is slowly being understood. There is an urgent need to have deeper understanding of these eco-biological links and develop the skill to predict the impacts under different scenarios. This would help to increase the preparedness of the fishers against fishery declines.

Though, there are rules protecting the habitats from unplanned human activities, these are not strictly implemented. Understanding the need to reduce the anthropogenic activities on habitats, it is suggested that micro- level environment management plans are developed in close association with the researchers and the coastal villagers. Effective implementation of co-management systems would help in effective governance.